ON SPONGES AND THEIR USE IN SURGERY.

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FEW of the common needs of a surgical operation are in more general and constant requisition than sponges. They are above all the most efficient means we can employ for the particular ends required. It is, however, purely in their physical effects, that their efficiency rests. Nothing absorbs so well, nothing so conveniently conveys fluid to a part; and yet, with these advantages, their use may be fraught with the greatest possible danger. A sterile or aseptic sponge is safe in its use as well as efficient; but a sponge not sterile may contain within it seeds of disease. It is with this question of the sterility of sponges, that the following remarks are concerned.

A sponge, to all external appearance, may look perfectly clean and smell quite sweet, and yet, when employed at an operation, contain within it that which will give rise to a fatal issue. It was owing to such an unfortunate result in one case, and the nearness of a similar issue in another, that I was led to look into this matter regarding the sterility of sponges.

In discussing this subject, it is very necessary to give, first of all, some short account of the nature of sponges; their mode of acquirement and method of preparation; for not a little of their ultimate efficiency depends on certain features connected with one or other of these points.

Nature of sponges.—The sponges, as we see them in ordinary use, consist of a skeleton or framework of horny, elastic fibres, which interlace in every direction. This framework is composed of a substance called keratode, and is itself in the natural state, when living, coated with a soft gelatinous material, called sarcode. The skeleton is strengthened by calcareous or more generally by siliceous spicules. When examined under the microscope, the fibres composing the framework are seen to be transparent, uniform in their calibre and structure, although some are narrower than others. The fibres join freely in all directions, producing spaces, which may be of any shape or size.

If a piece of sponge be finely teazed out; placed under a cover glass on an ordinary microscope slide and a drop of water deposited just at the edge of the specimen, it will be seen, by using a moderately high power of the microscope, that the fibres of the sponge gradually swell as the water creeps along the tissue, thus showing the actual affinity, which the latter has for fluids. The keratode very readily takes up and fixes aniline dyes and by thus staining the fibres, a very pretty and distinct appearance is given to the sponge framework.

Sponges cannot be used in fluids where the temperature exceeds about 90° F. They then begin rapidly to shrink, and, if allowed to remain any time, no matter how short, in boiling water they soon acquire a dark brownish color. A sponge, which has thus been shrunken, maintains its diminished size, and although still absorbent, has acquired a peculiar elastic character. A small piece of its tissue, thus boiled, is seen microscopically to have undergone considerable changes. There is no longer any regularity or translucency in the fibrous meshwork of the tissue. The fibres have become much deeper in color and almost opaque. They are split and fractured, and present irregular excrescences The whole shows also great contraction from the diminution in size and shape of the interfibrous spaces. A sponge, which has been boiled so as thus to have its intimate structure destroyed, becomes on drying perfectly hard, like a piece of wood.

The acquirement and preparation of sponges.—The sponges, which are in general use, are obtained either from the Mediterranean, from the West Indies or from the coast of Florida, The Mediterranean, or as they are better known, the Turkey sponges, are the finest and most expensive. These sponges, when fished up, are subject to the following process:

On removing the sponges from the water, the gelatinous matter, which is of a brownish yellow color, and of a decidedly fishy odor, begins to run freely from it. It is necessary, however; to hasten this process in order to prevent the evil effects of putrefaction. For this purpose the sponge gatherers dig round, shallow holes in the sand along the shore which are filled with water. In these the living sponges are placed and then trampled upon until the canals are entirely free of the gelatinous protoplasm, sarcode, or "milk of the sponge," as the fishermen call it, and nothing remains but the keratose skeleton, known as the sponge of commerce, together with a certain quantity of sand, taken in at the pores, during the process, and which is got rid of afterwards. After this, they are packed in bales and exported.

On reaching the wholesale dealers, they are subjected to baths of dilute muriatic acid and permanganate of potash, and when subsequently dried are ready for the market.

The sponges which perhaps are more largely and frequently used in hospital surgical work, from the fact of their much greater cheapness as compared with the Turkey sponges, are from the West Indies and the coast of Florida. From the account given in the *Pharmaceutical Journal*, of the acquirement and preparation of sponges obtained off the coast of Florida, it appears that the process is somewhat different to that adopted in the case of the Turkey sponges. As soon as the sponges are fished up and brought on board, they are carefully spread over the deck of the vessel, in their natural upright position, so as to allow the slimy matter, called "gurry" by the spongers to run off easily. During the first stage of decomposition, they smell strongly of ammonia and are extremely noxious. Later the ammonia scent disappears, leaving a stronger one, very similar to that of decaying sea-weed. Sponges, if kept on deck, will generally die and lose the greater part of their gelatinous matter in one or two days, therefore, when thrown into the crawls (an enclosure of stakes 8 or 10 feet square, situated in water 2 to 4 feet deep) the chief part of the curing to be done is the removal of the outside skin or covering. In cold weather they live much longer than in warm. In summer, and when they are dead at the time they are placed in the crawl, the week's soaking that they undergo softens all the remaining slime and skin they contain, and a little squeezing and beating with a short, heavy stick, called a "bruiser" suffices to clean them completely. They are squeezed as dry as possible and thrown into a dingy to be strung in the form of bunches on rope yarns, six feet long. This is to allow them to bleach and dry. They are afterward stowed in the hold. When dry they are in condition to sell to the wholesale merchants.

In order to give the sponges a bright yellow color, which adds to their value; they are what is called "limed." This process consists in dipping them into a weak solution of lime and sea-water, after which they are hung up out of doors to dry. If an excess of lime is used, the tissues are injured and the sponges become rotten and worthless; and if also they are not completely dried they soon become ruined.

These, then, are some of the facts connected with the life history of sponges and their process of preparation for commerce. I propose now to point out, wherein I venture to think lurk some of the dangers that may render them often unfit and unsafe for surgical purposes.

Part of the process of preparation consists in the removal of the gelatinous material or sarcode from the sponges. This is effected in the case of the Florida sponge by squeezing and beating, and in that of the Turkey sponge by trampling. According to the efficiency with which the process is carried out, will the sponge be more or less completely deprived of its gelatinous sarcode. Where incompletely removed the center or densest part of the sponge would be the most likely part for its retention. Before packing, the sponges are dried, so that what remains of the dead—possibly putrified—Sarcode is retained in the center of the sponge, inert and harmless until by moisture, heat and other favorable conditions, the microbes therein embedded are enabled to reach new fields and produce such results as they may be capable of. On arrival in this country, however, sponges are submitted to further processes of cleansing, which may have some slight antiseptising effect. Thus, as already stated they are subjected, to baths of dilute hydrochloric acid and permanganate of potash. This, while possibly effecting some degree of cleansing, does not, as I shall shortly show, render a sponge, without further treatment, fit for surgical purposes.

Another source from which sponges suffer in the process of preparation, is the "limeing" which they undergo, in order to give them a bright straw yellow color. Here, as above indicated, any carelessness in the process may cause considerable injury to the sponge structure. The only way, however, in which this injury to the tissue may effect the value of a sponge surgically, is, that when limed, or incompletely dried after the limeing, they may last but a short time.

I dare say it is not unfamiliar to many, the peculiar, soft, almost slimy like condition into which a sponge often gets, after being in use for some time. What precisely this is due to, it is hardly possible to say, but fairly suggestive causes, I think, may be found in what has immediately preceded. Mr. Rose of the Sauchiehall street branch of the Glasgow Apothecaries' Company, to whom I am much indebted for information of various kinds, connected with the present subject, tells me that this slimy-like condition of sponges is something new within recent years. He attributes it to a different process of preparation, to that employed many years ago. At that time the sponges were not so rapidly prepared. They were buried for a considerable time in the sand before being further treated. Such a prolonged process would render it much more probable that all the Sarcode would be removed from the fibrous meshwork of the sponge. One possible explanation of this peculiar change in the consistency of the sponge may be due, then, to imperfect removal of the sarcode. The only feature against this conjecture, and that a not unimportant one, is that time and constant use should further improve the sponge by the sarcode gradually escaping. The sponge, however, never does again recover its original condition. It would seem, therefore, that another explanation must be sought for. A not unreasonable one is to be found in the process of limeing. As already shown, this, if not carefully carried out, will completely ruin the sponge. It may therefore be, that the condition under discussion, owes its origin to some defect in this part of the process. That it does not occur in all sponges renders some such explanation the more probable.

I must now leave this introductory discussion on sponges, and turn to that which was the real incentive to my taking up the subject.

I had performed the operation of ovariotomy. The cystoma had an unusually broad pedicle. Some difficulty arose in connection with bleeding points, and it was necessary to check hæmorrhage by pressure. This was efficiently effected by a sponge. Forty-eight hours afterwards the sponge was removed and found to be septic. Fortunately the patient was but slightly affected and made a good recovery. In the second case above alluded to, where a fatal issue resulted, a sponge was left in the abdomen, through the nurse having divided one at the time of the operation, and forgetting that thereby an additional sponge had been added to the original number. The patient died and a sponge was found in the abdomen, the center of a fœtid abscess. With my own experience in the first case and the coming before my notice of this latter, where on both occasions I had reason to know that the operations were performed with all proper antiseptic precautions, I felt that the mischief which had arisen in both cases must have been connected in some way with an inefficient mode of rendering the sponges sterile. The more so, from the fact, that in both cases the sponges were prepared in precisely the same way.

Actuated by this feeling, I determined to have some sponges prepared for me as those had been prepared for the operations, and subject them to some experimental tests.

The sponges were taken new—as supplied from the hospital store—thoroughly rinsed in hot water and then placed in a solution of carbolic acid (1 in 40) for the night prior to the operation. On the morning of the operation they were placed in a fresh solution of the same.

Two sponges so prepared—a Cuban wool (which is an open textured sponge) and a Cuban fine (which is a close or dense textured sponge) were squeezed by the hand as free as possible of the carbolic solution, and then each divided by a sterilized pair of scissors. From the center of one sponge so divided, small pieces were removed by another pair of sterilized scissors and inserted into tubes of Koch's beef-peptone jelly, previously liquified. Pieces also were taken from the other sponge in the same way and inserted into similar tubes of jelly. The tubes—two of each—were placed in the incubator and left at a temperature of 37° C. for forty-eight hours. On examination of the tubes at the expiry of this time, the two containing pieces from the dense or close textured sponge were muddy in appearance, while those containing pieces from the open textured one, were quite clear. A microscopical examination of the muddy jellies showed them to be loaded with microbes.

Thus experimentally, one had been able to show that the sponges—although prepared with great care and every intention that they should be clean and fit for use, were not rendered aseptic. The 12 to 18 hours immersion in a 1 to 40 solution of carbolic had not asepticised the close textured sponges, but apparently had done so the open textured ones.

The same experiment was repeated a second time, except that I prepared the sponges myself. One of each kind of sponge was taken and thoroughly washed in hot water. (This washing brings out usually a considerable quantity of fine sand, which renders the water milky in appearance). The two sponges were placed in a 1 to 40 carbolic solution, where they remained for twenty-four hours. Each was divided and pieces removed from the center and placed in jelly tubes, in the same manner as above described. The tubes were placed in the incubator for forty-eight hours. Development of microbes took place in the tubes containing the pieces from the dense textured sponge; none in those containing pieces from the open textured one.

Still a third time the experiment was repeated, only on this occasion with pieces of the dense textured sponge alone, and just as above, extensive development of microbes took place in the tube, *i. e.*, rapidly in those placed in the incubator, more slowly in those left in the room at the ordinary temperature.

These experiments seemed to prove, with little room for doubt, the inefficiency of solutions of carbolic acid of a strength of 1 to 40, to sterilize the central part of close textured sponges, but its power to do so, in the case of loose textured ones. This failure on the part of carbolic acid led me to try the sterilizing power of solutions of bichloride of mercury. I did not test stronger solutions of carbolic acid, because, among other reasons, sponges used direct from such solutions would be inconvenient, if not sometimes harmful, and at all times expensive from the quantity of solutions required. Since my object, therefore, was a practical one, I made use of solutions that could be used in large quantities, and for this purpose I chose a 1 in 2000 solution of mercuric perchloride, such as is in common and constant use in surgical practice.

The Cuban fine or dense textured sponges were alone used. The sponges were thoroughly washed and frequently rinsed. They were then placed for twenty-four hours in the mercury solution, at the end of which time pieces were inserted from the center of the sponges into tubes of jelly. Two tubes were placed in the incubator and two in the room. No development of microbes occurred at any time subsequently. Thus it appeared that the mercury solutions had succeeded, where the carbolic had failed.

To test more severely the relative sterilizing power of the two solutions already used and to eliminate a possible objection against the last experiment—that no control had been made and that therefore the sponges from the first may have been aseptic—the following experiment was performed.

A Cuban fine sponge was placed immediately against or over the orifice of a discharging sinus situated in the thigh of a patient suffering from necrosis of the femur. When removed from the wound on the following day, it contained a quantity of excessively fœtid pus. The sponge was placed in a glass receptacle and kept until the following day, and when then exposed it smelt about as bad as it well could. The sponge was taken from the receptacle, rinsed and squeezed several times in hot water. After this washing it still maintained an offensive smell, which was more marked in the center of the sponge after it had been divided.

Each half was now put into a separate receptacle, the one containing a solution of carbolic acid of a strength 1 in 40, the other a solution of bichloride of mercury of a strength 1 in 2000. They were left in this solution for eighteen hours when tube cultivations were made in the way already described. Two tubes of each were placed in the incubator.

On the following day the two tubes containing the carbolized fragments had each a dense opaque scum upon their surfaces while the two tubes containing mercurialized fragments were perfectly clear.

Why carbolic acid of a strength 1 in 40 should fail to have any sterilizing power appears at first sight, for many reasons, rather puzzling. Thus, I have frequently made solutions of this strength with ordinary unboiled water—such as it flows from the tap in my laboratory—and while cultivations made from the pure water itself always revealed the presence of microbes, those made from the same water into which carbolic acid to the above strength had been added, no such existence of microbes was ever detected. Microbes, therefore, floating freely in water were killed, but existing in the heart of a sponge, they were unaffected. The possibility occurred to me that the sponge tissue might have some special affinity for carbolic acid and so, in a way, filter it from the solution, which reached the deeper parts. This led me to try a simple experiment in support or otherwise of this possibility. A piece of sponge was tightly squeezed into a glass tube, and the tube—open at both ends—held perpendicularly. A very weak solution of carbolic acid—1 in 100—was then poured into the tube at the upper orifice, allowed to percolate through the compressed sponge and collected in a small glass flask, placed beneath the lower orifice. The fluid so filtered, and an equal quantity of the same, which had not been used, were then treated with equal quantities of perchloride of iron, with the result that, so far as the eye could detect, no difference in the colorization produced existed in the appearance of the two flasks; in other words, no carbolic acid appeared to have been taken from the solution in its passage through the sponge.

The real explanation of this apparent contradiction of the action of carbolic acid upon the microbes in the tap water and those in the sponges is to be found, I believe, in the difference of the species of microbes acted upon.

I know, from the many examinations I have made of the water in my laboratory, that it is almost entirely free from putrefactive microbes, while many of those present in sponges are of this class. So that it would appear that the difference of the action of carbolic acid is to be explained, on the one hand by its germicidal effect upon non-putrefactive microbes, and on other hand by its inertness upon saprophitic and pathogenic microbes. This very fact of the inefficient sterilizing power of 1 to 40 solution of carbolic acid on saprophitic and pathogenic microbes has been attested by many. Thus, it has been shown by cultivation experiments that instruments dipped in solutions of this strength are not properly sterilized. Little wonder, then, if the complex structure of sponges containing within their dense and intricate fibrous meshwork dried masses of sarcode should fail to be properly sterilized by this same solution.

The practical lessons, then, which these various experiments seem to teach are that sponges, which are most open in their meshwork are least likely to be septic from causes connected with their preparation ; that these same sponges are easiest to sterilize ; and that a solution of bichloride of mercury, of a strength of 1 in 2,000, is the best sterilizing medium. It follows from the above, that large sponges and thick, dense sponges are those most likely to be septic, and are those which will require some care in order to efficiently sterilize them.

Taking these various factors into consideration, the best sponges for surgical use are the small cup Turkey sponges. Their texture is close but their shape prevents them from being anywhere so thick that they would fall under the objection above mentioned. One advantage, also, of no little importance is, that in these sponges, there are not the same loose tags of tissue projecting from the surface, which so frequently exist on the surface of the more open textured kinds. They are about double the price of the Florida sponges, but their greater expense is quite compensated for by their convenience and safety.

When our sponges have been properly sterilized, how should we preserve them during the time they are not in use? Should we keep them dry in air-tight rubber bags, which protect them from any external contamination? Or should we keep them constantly immersed in some antiseptic solution? To ascertain whether sponges were in any way deleteriously affected by prolonged immersion in the commonly used antiseptic fluids, I took two Florida sponges (Cuban fine) placed one in a vessel containing 1 in 20 carbolic solution and the other in a vessel containing 1 in 500 mercury solution; both it will be seen very strong solutions of the antiseptics. The vessels were each covered by a cap of gutta percha tissue and left exposed to light in the laboratory. At the end of nine months I examined them. Both had darkened very slightly in color; the carbolic one more than the mercury one, but neither had suffered in consistency, nor could a microscopical examination detect any thing amiss in their minute structure. To all appearance they were in as complete a condition as when first inserted. The belief, which to some extent exists, that mercury solutions blacken sponges is, I believe, a fallacious one. It is not uncommon, for the sake of distinguishing the solution from other like colorless ones, to put a little aniline dye into it. Not unfrequently it is a little methyline blue. Now, the sponge texture has a great affinity for the dye, and will, as I have tried, completely decolorize a fluid so tainted. The sponge thus becomes darkened in appearance, due, therefore, not to the mercury, but to the dye.

Sponges, however, do in time darken, not from their being actually dirty, but from pigmentation or staining of the skeleton of the sponge from various causes. To remove this darkened appearance, they are subjected to different processes of bleaching. I will only mention two—permangano oxalic acid and the hyposulphite.

The former consists in first placing the sponge for a few minutes into a solution of permanganate of potash, 1 ounce of the salt to 4 pints of water, and then for the same time into a solution of oxalic acid made by adding 1 ounce of the acid to 4 pints of water. The result of this process is to make the sponge of a very pale, almost white color.

In the hyposulphite process the sponge is first steeped in a weak hydrochloric acid solution—1 in 10—then immersed in a bath composed of hyposulphite of soda, 1 part, hydrochloric acid, 2 parts, and water, 12 parts. This solution is then pressed out and the sponge well washed in cold water. It is finally placed in a bath composed of carbonate of potash, half an ounce. I have tried the former process and found it effectual but the latter I have not tested. I should be disposed to say that when a sponge has reached that condition, when a bleaching process appears necessary, it has well passed the time when it should be discarded for all surgical purposes.

I cannot conclude this discussion without referring to a consideration which must, I venture to think, very materially influence us in our use of sponges for surgical purposes.

Much has been discovered and is being discovered regarding the products of microbes, and the injurious effects, which these so called ptomaines or toxic albuminoses are capable of producing. How far, it may be asked, does the sterilizing of a sponge affect these? All we know is, that we can kill the microbes present, but we have no knowledge in what way, if in any way, we affect their products. Thus, then, it seems quite possible that a septic sponge might be rendered quite aseptic, as we understand it, and yet be the means of conveying toxic agents to a part. In consideration of this possibility, therefore, the right practice would appear to be, to discard forthwith all sponges which have been used for any distinctly septic cases.